Upright time and sit-to-stand transition progression after total hip arthroplasty: an in-hospital longitudinal study

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Abstract

Background:

Whilst early mobilization in-hospital is a key element of post-total hip replacement (THR) rehabilitation, it is poorly documented.

Methods:

To gain quantitative insight into in-hospital mobilization upright times and sit-to-stand transitions were measured using a thigh-mounted movement sensor in forty four participants (13M;31F), age 50-82y, in an observational, post-surgery, in-hospital, longitudinal study.

Results:

Some participants performed no activity in the first 24hrs following surgery. However, in the last 24hrs before discharge participants performed a median of 40 (IQR:15) sit-to-stand transitions and spent 134mins (IQR:74mins) upright. Activity in rehabilitation constituted 19.4% (IQR:15.8%) of sit-to-stand transitions and 13.3% (IQR:5.5%) of upright time. Females spent longer in-hospital (80hrs IQR:24) compared to males (54hrs IQR:26).

Conclusion:

Whilst there was considerable activity within rehabilitation periods a large majority of sit-to-stand transitions and upright time occurred outside rehabilitation. Within the Last 24hrs in-hospital all participants were upright for prolonged periods and completed numerous sit-to-stand transitions.

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List of Abbreviations

ASA American Society of Anesthesiologists Physical Status Classification

ERP Enhanced recovery programme

IQR Inter-quartile range

OT Occupational therapy

PA Physical activity

PT Physiotherapy

STS Sit to stand transitions

THA Total hip Arthroplasty

VAS Visual analogue scale

INTRODUCTION

Total hip arthroplasty surgery (THA) is performed to eliminate pain and improve function [1]–[3]. The process of rehabilitation to increase mobility and improve function starts whilst in hospital. The resumption of sit-to-stand transitions (STS) and engagement in upright activities are indicators of recovery. By monitoring these activities, it is possible to quantify improvement across the recovery time-line.

Healthcare organizations in the UK are increasingly adopting enhanced recovery programmes (ERP), optimizing patient recovery, with in-hospital rehabilitation aimed to return patients to independent performance of functional tasks. These programmes minimize time taken to recover by tailoring pain reduction medication to allow early rehabilitation and mobilization [4]–[6].

Pre- and post-THA physical activity (PA) outcomes have been reported previously [7], [8]. However, in-hospital activity has not been reported. This lack of quantitative evidence prevents informed discussion of the efficacy of therapy programmes and physical mobility promotion protocols. Objective measurement of PA would provide evidence to inform and evaluate rehabilitation programmes.

The aim of this study was to answer two questions: Firstly, what are the profiles of upright time and STS in-hospital following THA and secondly, is there a difference in these profiles between males and females?

MATERIALS AND METHODS

This was an observational, in-hospital, longitudinal study of upright time and STS following THA. Ethical approval was obtained from the West of Scotland Research Ethics Committee (12/WS/0098;13/WS/0302) before commencement. All participants gave written informed consent.

Participants were recruited consecutively within two time periods from patients undergoing THA from a single arthroplasty centre. Exclusions included; revision hip arthroplasty, previous total hip/knee arthroplasty in the last 6 months, severe locomotor limitations due to cardio-pulmonary, central or peripheral nervous system deficits and spinal conditions or diagnosed terminal disease.

To characterise the population taking part in the study pre-operative assessments were performed. These included patient and clinician based assessment; the American Society of Anethesiologists Physical Status Classification (ASA) [9], Oxford Hip Score [10], Harris Hip Score [11] and EQ-5D (EuroQol), both index and visual analogue scale (VAS) [12]. Capability of participants was assessed using hip muscle strength (using a hand held dynamometer to measure hip flexion and abduction) [13], walking speed (10m walk test, speed over middle 6m) [14], walking endurance (six minute walk test) [15] and ability to rise from and return to a chair (timed up and go test) [16]. In addition demographic data were collected from the patient records.

All participants were operated on by a single consultant surgeon (DA) (or trainee under supervision). Exeter® femoral component and either Contemporary® cemented cup or Trident® uncemented cup with an X3 polyethylene liner (Stryker Orthopaedics[a], Michigan, USA) were inserted using a posterior approach. Peri-operative care (from pre-assessment through discharge), following the institution’s ERP [6], was aimed at promoting safe independent mobility and discharge as quickly as possible. The standardized procedure within the hospital at the time was: operations were carried out under spinal anesthesia with sedation as required; Local intra-articular infiltration was used in theatre with 180ml of 0.2% ropivacaine injected into the joint; Post-operative analgesia included strong opiod (oxycodone or fentynal transdermal patches) with PRN oxynorm and tramadol; Post-operative epidural catheters were not used.

Rehabilitation in-hospital included both physiotherapy (PT) and occupational therapy (OT). From the day of surgery (day 0) a physiotherapist regularly assessed the participants' blood pressure, muscle power (myotomes) and sensation (dermatomes). When sensory and motor functions had returned to both lower limbs, mobilisation started from bed to chair with wheeled walking frame and assistance of two staff. Progression was made to either elbow crutches or walking sticks and to independent walking. Walking practice was complemented with exercise programmes, to strengthen and stretch the hip/knee, and to aid gait-retraining. Participants practiced stairs, mimicking their home environment, to ensure safety prior to discharge. Participants were seen, on average, twice a day by PT for 15-30mins. Participants who were successfully mobilised on day 0 started OT on day 1, otherwise when deemed fit by the Occupational Therapist. OT was function based, focusing on activities of daily living (personal care tasks, transfers, domestic tasks). Once participants had achieved essential functional tasks necessary for activities of daily living, they were discharged from OT. Post–operative treatment time within OT was approximately once/day for ~30mins.

Outcome measures

The primary in-hospital outcomes were upright time, the number of STS (performance of posture changes), and the longest upright bout (longest period the upright posture was maintained). Secondary outcomes were time in-hospital to discharge from rehabilitation and ward and any post-operative side-effects. Post-operative side-effects, such as nausea and vomiting, that could have affected ability to mobilize and therefore to complete the rehabilitation criteria were collected from the patient case notes.

Primary in-hospital outcomes were measured objectively using a physical activity monitor (activPAL3^{TM}, PAL Technologies Ltd[b]. Glasgow, UK, version 7.1.18, 50x35x7mm, 30g). The original activPAL^{TM} has proven validity for the measurement of upright times and upright events in adults [17] and older adults [18], [19]. Within 4hrs of participant return to ward (still in bed), the monitor was attached to the anterior aspect of the thigh of the non-operated leg using a waterproof surgical dressing (Duoderm extra thin hydrocolloid dressing (Convatec) or Opsite flexifix (Smith & Nephew)), for 24hr/day wear. Data was collected continuously for the entire post-operation, in-hospital period.

In-hospital outcomes were calculated from the activePAL data using custom software for the following time periods:

- Total: The entire post-surgery in-hospital stay.
- First 24hrs: The first 24hrs after monitor application to characterise initial activity post-surgery.
- Last 24hrs: The last 24hrs before discharge from PT/OT, to attempt to characterise the maximum activity within a 24hr period in-hospital.
- Rehabilitation: The time associated with PT/OT. It was assumed that activity within the 30mins preceding the logging of the end point of PT/OT was 'associated' with rehabilitation. This approximation was made based on verbal feedback from PT/OT about the typical length of therapy. The % of total activity associated with PT/OT was calculated.

Secondary outcomes were collected from the patient records.

DATA ANALYSIS AND STATISTICS

Not all data sets were normally distributed (Shapiro Wilk), therefore, to maintain consistency analysis was performed using non-parametric statistics. Median, interquartile range and min/max values describe outcomes. A comparison of male and female outcomes was made (Mann Whitney U test). A point estimate (95% confidence interval) of the difference between gender outcomes was calculated. A significance level of $p<0.05$ was used (Minitab 17, Minitab Inc.).

RESULTS

Fifty (16M/34F) participants were recruited from 125 patients (Figure 1) undergoing THA. Complete data sets were recorded from 44 participants (13M/31F), median age 68y (50-82) and median BMI 29.7kg/m^2 (23.2-43.3) (Table 1). All participants were of Scottish White origin.

Pre-operatively there were no statistically significant differences between male and female participants in ASA, Oxford Hip Score, Harris Hip Score or the EQ-5D Index or VAS ($p\geq0.219$) (Table 1). However, males had stronger hip flexors (median difference 5.7N, 95%CI: 1.3,10.4; $p=0.012$) and abductors (median difference 3.7N, 95%CI: 1.2,5.7; $p=0.002$) than females and performed the timed up and go test faster (median difference -2.7s, 95%CI: -5.2,-0.2; $p=0.035$). Whilst males tended to walk faster over the 10m walk test (median difference -0.18m/s, 95%CI: -0.10,0.48; $p=0.208$) and travel further during the six minute walk test (median difference 56m, 95%CI: -6,120; $p=0.070$) than females these differences were not statistically significant.

Discharge from rehabilitation (PT/OT) occurred at 68hrs (IQR:24) with discharge from hospital at 74hrs (IQR:25) (Table 2).

Overall during the first 24hrs after return to ward there was considerable variation in the STS (0-61), total upright time (0-232mins) and longest upright bout (0-68mins) (Table 2). There continued to be similar high levels of variation in outcomes in the last 24hrs before discharge with 18-78 STS, 51-429mins of upright time and a longest upright bout of between 5-85mins. Time in-hospital and the time spent upright varied widely (Figure 2). Additionally side-effects of operation were noted (Figure 2). Overall 19.4% (IQR:15.8) of the total number of STS and 13.3% (IQR:5.5) of upright time was associated with rehabilitation time (Table 2).

Females stayed a median of 20hrs (95%CI:0-25) (42%) ($p=0.035$) longer in hospital to the point of discharge from therapy than males and 22hrs (95%CI:3-37) (41%) ($p=0.008$) longer to discharge from the ward. In the first 24hrs following return to ward males had more STS (95%CI:5-14) ($p<0.001$), longer total upright time (95%CI:18-61mins) ($P<0.001$) and longer longest upright bout (95%CI:1-13mins) ($P=0.007$) (Table 2) than females. However, in the 24hrs before discharge there was only a statistical difference in the longest upright bout with males having longer bouts than females (95%CI:1-17mins) ($p=0.037$). Side-effects were noted for only 1/13 males, but for 17/31 females (Figure 2).

DISCUSSION

This is the first report of in-hospital PA following THA and provides insight into typical activity following operation. This objective analysis highlighted the considerable volume of activity performed both within and outside of rehabilitation sessions and the considerably slower recovery of females compared to males. The age, OHS and self-reported quality of life (EQ-5D index and VAS) for this sample were similar to those reported for hip replacement patients across the UK [20]

In the first 24hrs post-surgery some participants remained in bed, usually due to slow recovery from anesthesia. Side-effects that limited the implementation of therapy included low blood pressure, nausea, vomiting and individual specific health problems. The change between the first 24hrs after surgery and the last 24hrs before discharge reflects several factors including recovery from anesthesia, efficacy of pain medication and rehabilitation participation. Within the last 24hrs higher PA levels were achieved with a median of 40 STS and 134mins upright. However, there was a large variation in outcomes (Figure 2), perhaps reflecting personal choice. Within the 24hrs before discharge the longest upright bouts were considerable (5-85mins) demonstrating the possibility of extended periods of standing for most participants. Whilst STS and upright time post-THA in-hospital do not appear to have been previously reported, these outcomes have been reported (12hr/day) for older adults admitted to day hospital (230mins upright, 57 STS/12h), older adults admitted to a ward for rehabilitation (79mins upright, 36 STS/12h) and an age matched (74±6y) healthy population (360mins upright, 71 STS/12h)[21], [22]. In the current study participants had levels above those admitted to a ward for rehabilitation, but lower than those admitted to a day hospital.

Rehabilitation accounted for almost 20% of STS and 13% of the total upright time, demonstrating there was considerable activity within these periods, yet the majority of PA was completed by personal choice (or necessity) outside the formal rehabilitation sessions. This must be considered when developing motivational strategies for encouraging PA within hospital. As part of the ERP participants were encouraged by the multidisciplinary team (surgeon, PT/OT, nurses) to be as active as possible, getting up and walking around. Previous research with different patient groups has demonstrated the effectiveness of a multi-disciplinary team approach to in-patient rehabilitation [23]–[25]. This may be one reason for the relatively large proportions of STS (~80%) and upright time (~85%) outside rehabilitation.

Females were slower to mobilize and tended to lag behind males' activity by ~24hrs, giving longer time to the point of discharge from rehabilitation (females' median 69hrs; males' median 48hrs). Within this cohort females had a much higher incidence of nausea and vomiting, low blood pressure or tiredness (Figure 2). It is clear that these factors may have delayed the initiation of or temporarily stopped rehabilitation ultimately leading to a longer stay in hospital. However, based on the results collected for this study it was not possible to determine if there was a causal relationship between these factors.

The samples of male and female participants studied had similar pre-operative self and clinician-assessed scores. However, before surgery males were stronger and were able to perform the timed-up and go test faster than females. Males and females did have similar speed of walking and endurance. It is possible that these differences in strength and ability to perform the standing and turning movements were critical in determining the course of recovery allowing males to engage with activity earlier than females. However, it is clear that limitations in pre-operative hip strength and ability to stand from a sitting posture were not great enough to prevent locomotion. Perhaps in conjunction with weakness caused by tissue disruption during surgery, the lower levels of strength and capacity in females may have limited early activity engagement.

This study has a number of limitations. Participants were recruited from one hospital under the care of one surgeon possibly limiting generalizability. Characterisation of activity associated with PT/OT used an assumption about the time period of analysis. This could have led to an overestimation of the activity associated with rehabilitation. Post-operative side-effects were more frequent for the females than males, which may have caused differences in outcomes. However, this study was not powered to systematically investigate this effect.

CONCLUSION

This is the first study to quantify upright time and sit-to-stand transitions in-hospital following THA. The objective outputs reported here, as derived from a body-worn sensor, reveal that patients are performing considerable activity both within rehabilitation sessions and outside of these times. The values obtained here for the outcome measures can be used as reference values for further research. This analysis provides invaluable insight into patients' response to the rehabilitation regime and recovery post-THA.

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Suppliers

[a] **Stryker Orthopaedics**, Michigan, USA: Exeter® femoral component, Contemporary® cemented cup, Trident® uncemented cup, X3 polyethylene liner.

[b] **PAL Technologies Ltd**. Glasgow, UK: activPAL3™

List of Figures Legends

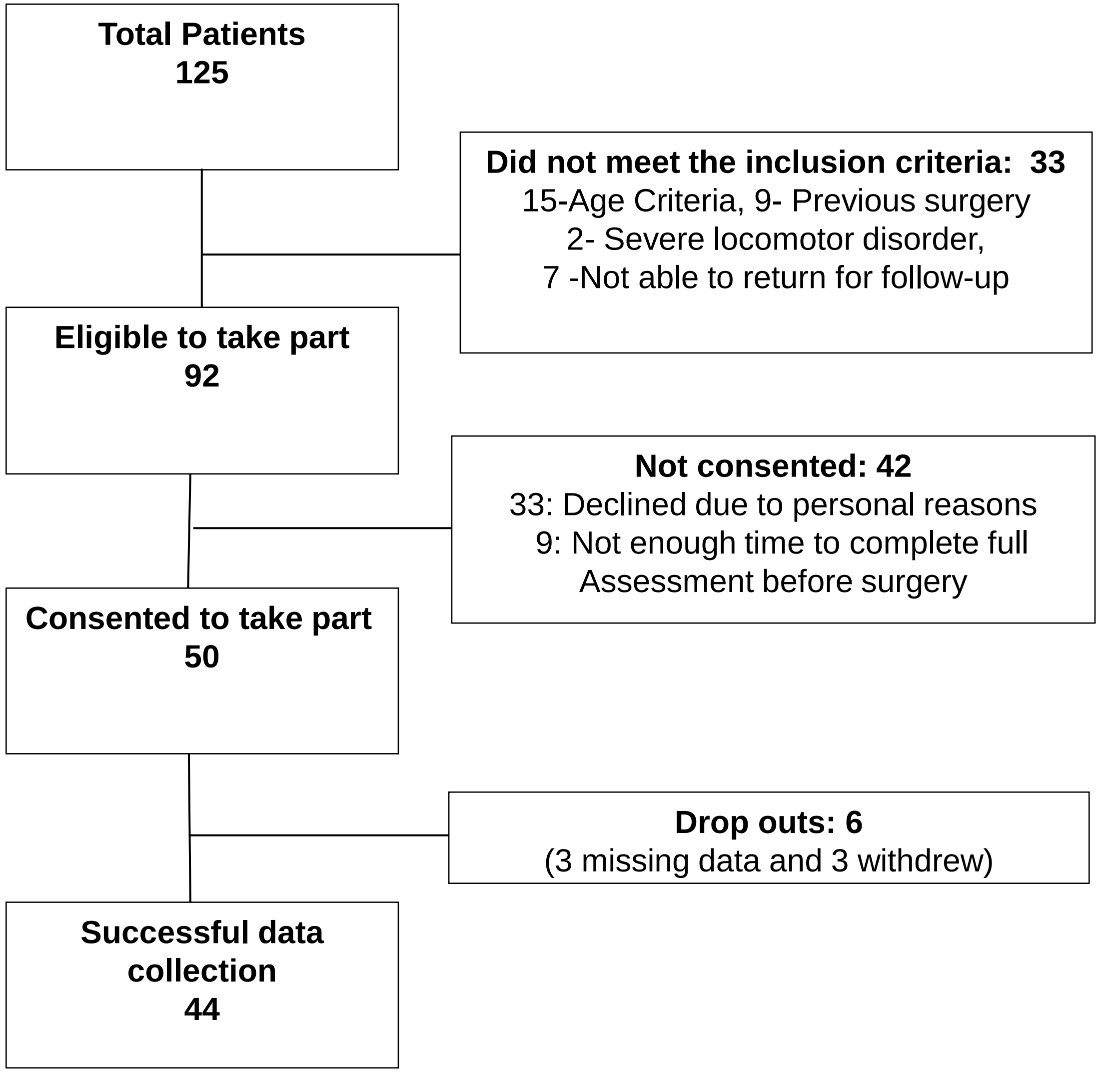
Figure 1

Strobe flow chart of participant recruitment.

Figure 2

All participants' upright time as a percentage of each hour (0-100%). Twenty four hour time blocks marked as per key. First 100% line indicates start of record and last 100% line indicates end of record for each individual. Female (left) and Male (right) outcomes are illustrated ordered by age of participant (years).

Post-operative side-effects affecting mobilization: *=low blood pressure; $=nausea and vomiting; #=other including headache, mild fracture, dizziness, vaso vagal issues, reduced confidence, delayed sensory and motor recovery, delirious and confusion, atrial fibrillation.


Total Patients
125
Did not meet the inclusion criteria: 33
15-Age Criteria, 9- Previous surgery
2- Severe locomotor disorder,
7 -Not able to return for follow-up
Eligible to take part
92
Not consented: 42
33: Declined due to personal reasons
9: Not enough time to complete full
Assessment before surgery
Consented to take part
50
Drop outs: 6
(3 missing data and 3 withdrew)
Successful data
collection
44

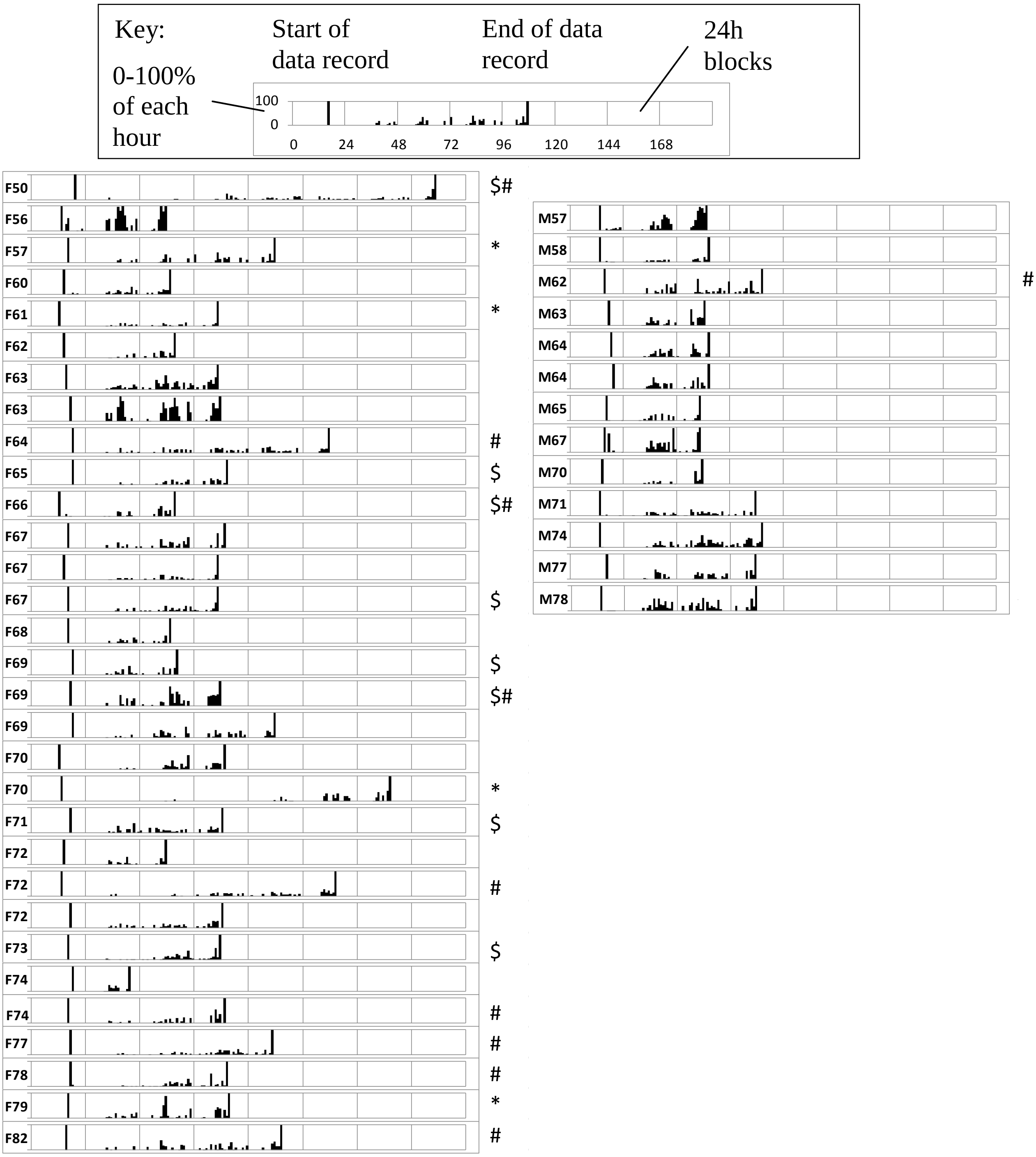


Figure 2 All participants' upright time as a percentage of each hour (0-100%). Twenty four hour time blocks marked as per key. First 100% line indicates start of record and last 100% line indicates end of record for each individual. Female (left) and Male (right) outcomes are illustrated ordered by age of participant (years).

Post-operative complications affecting mobilization: *=low blood pressure; $=nausea and vomiting; #=other including headache, mild fracture, dizziness, vaso vagal issues, reduced confidence, delayed sensory and motor recovery, delirious and confusion, atrial fibrillation.

Table 1 Participant demographic details and pre-operative scores. Differences in outcomes between male and female are given with point estimate of difference (*) and 95% confidence interval (CI) of the difference (p-value from Mann Whitney U test). (IQR = interquartile range)

	All participants (44)	Male (13)	Female (31)	Male-Female difference	
	Median (IQR) [range]	Median (IQR) [range]	Median (IQR) [range]	Difference* (95% CI)	p-value
Age (*years*)	68 (9) [50-82]	65 (8) [57-78]	69 (9) [50-82]	-2 (-6,4)	0.562
Height (*m*)	1.65 (0.12) [1.50-1.82]	1.73 (0.05) [1.54-1.82]	1.62 (0.09) [1.50-1.73]	0.11 (0.07,0.15)	<0.001
Weight(*kg*)	81.5 (23.5) [60.0-132.6]	93.0 (14.4) 74.5-132.6]	71.0 (17.5) [60.0-120.4]	20.1 (11.6,28.6)	0.001
BMI (kg/m^2)	29.7 (6.5) [23.2-43.3]	31.7 (5.4) [26.7-43.3]	27.9 (5.9) [23.2-40.5]	3.0 (0.0,6.4)	0.052
Pre-operative scores					
ASA	2 (0) [2-3]	2 (0) [2-3]	2 (0) [2-3]	0 (0,0)	0.607
Oxford Hip Score (*48*)	16 (7) [5-42]	17 (6) [8-22]	15 (7) [5-42]	0 (-5,4)	0.928
Harris Hip Score (*100*)	52 (12) [27-68]	55 (10) [30-60]	51 (12) [27-68]	0 (-6,7)	0.990
EQ-5D-5L Index (*1.000*)	0.341 (0.251) [-0.080-0.698]	0.345 (0.300) [0.081-0.604]	0.336 (0.258) [-0.080-0.698]	0.052 (-0.094,0.195)	0.528
EQ-5D-5L VAS (*100*)	55 (33) [10-100]	60 (25) [30-95]	50 (35) [10-100]	10 (-5,25)	0.219
Hip flexion strength (*N*)	56.4 (38.2) [23.6-129.3]	73.4 (46.5) [30.5-124.9]	53.1 (27.1) [23.6-129.3]	5.7 (1.3,10.4)	0.012
Hip abduction strength (*N*)	46.3 (20.5) [18.2-113.9]	54.3 (12.0) [30.3-113.9]	38.8 (21.0) [18.2-63.2]	3.7 (1.2,5.7)	0.002
10m walk test (*m/s*)	0.95 (0.51) [0.38-2.30]	1.03 (0.63) [0.38-2.30]	0.92 (0.52) [0.38-1.73]	0.18 (-0.10,0.48)	0.208
Six minute walk test (*m*)	264 (137) [105-476]	330 (144) [153-476]	243 (122) [105-421]	56 (-6,120)	0.070
Timed up and go test (*s*)	13.5 (5.4) [7.8-27.3]	11.7 (3.8) [8.3-24.6]	14.6 (4.9) [7.8-27.3]	-2.7 (-5.2,-0.2)	0.035

ASA=American Society of Anesthesiologists Physical Status Classification

VAS=visual analogue scale outcome

Table 2 In-hospital durations and physical activity outcomes for all participants and for males and females. Differences in outcomes between males and females are given with point estimate of difference (*) and 95% confidence interval (CI) of the difference (p-value from Mann Whitney U test). (Rehab = rehabilitation; STS = sit-to-stand transitions; D/c = discharge, IQR = interquartile range)

		All participants (44)	Male (13)	Female (31)	Male-Female difference	
	Outcome	Median (IQR) [range]	Median (IQR) [range]	Median (IQR) [range]	Difference* (95% CI)	p-value
Time to discharge	D/c from Ward (*hrs*)	74 (25) [44-188]	54 (26) [45-94]	80 (24) [44-188]	-22 (-37,-3)	0.008
	D/c from Rehab (*hrs*)	68 (24) [21-160]	48 (25) [42-73]	69 (15) [21-160]	-20 (-25,0)	0.035
First 24 hours after operation	STS	9 (8) [0-61]	16 (9) [6-61]	8 (6) [0-27]	9 (5,14)	<0.001
	Total Upright (*mins*)	25 (37) [0-232]	66 (47) [16-232]	14 (21) [0-199]	40 (18,61)	<0.001
	Longest upright bout (*mins*)	7 (6) [0-68]	10 (15) [4-45]	6 (4) [0-68]	6 (1,13)	0.007
Last 24 hours before D/c	STS	40 (15) [18-78]	40 (15) [18-78]	40 (16) [21-72]	2 (-6,11)	0.728
	Total Upright (*mins*)	134 (74) [51-429]	169 (77) [71-420]	132 (47) [51-429]	33 (-11,74)	0.165
	Longest upright bout (*mins*)	16 (17) [5-85]	27 (13) [5-78]	14 (10) [7-85]	10 (1,17)	0.037
Rehab activity	STS	16 (12) [7-38]	17 (12) [7-34]	16 (12) [7-38]	0 (-5,6)	0.990
	Total Upright (*mins*)	39 (24) [11-141]	41 (31) [17-86]	36 (25) [11-141]	7 (-9,20)	0.368
(% of total)	STS (*%*)	19.4 (15.8) [5.3-43.4]	23.1 (8.8) [15.2-30.8]	17.9 (21.7) [5.3-43.4]	2.4 (-6.6,8.7)	0.537
	Total Upright (*%*)	13.3 (5.5) [3.5-40.2]	12.8 (2.9) [8.1-19.4]	13.9 (8.8) [3.5-40.2]	0.2 (-3.4,3.8)	0.918